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THE EARTHQUAKE OF NOVEMBER 4, 1877.

(Read at the November Meeting of the Natural History Society, by PRINCIPAL DAWSON, LL.D., F.R.S.)

In the *Canadian Naturalist*, Vol. V., first series, will be found notes on the earthquake of October 17, 1860, with a summary of facts relating to the previous shocks recorded in Canada, and some general remarks on their periods, local peculiarities and probable causes. The subject was continued in Vol. 1. of the new series, in connection with the earthquake of April, 1864, and in Vol. V., new series, in connection with that of October 20th, 1870. I may refer to these notices for what is known on Canadian earthquakes up to that time, and we may now continue the narrative in connection with the somewhat wide-spread disturbances of the earth's crust in the present autumn.

On January 4th, 1871, a shock was experienced at Hawkesbury, Ontario, but was not reported from any other place. A more extensive earthquake occurred on May 22nd, 1871. It prevailed from the city of Quebec to the western part of Ontario. The time for Quebec is stated at ten minutes before two a. m., and there was a second shock at twenty minutes past three. The time for Perth, Ontario, is stated at half-past one. It is noteworthy that this earthquake occurred at nearly the same time with that recently experienced. Since 1871 several minor shocks have been noticed from time to time, but did not attract much attention, and I have preserved no details in relation to them.

That of the present month was probably the most considerable since 1871. It occurred at Montreal, at ten minutes before two on the morning of Sunday, November 4th. At Montreal there was only one distinct shock, preceded by the usual rumbling noise, and sufficiently severe to be distinctly felt, and to shake window-sashes and other loose objects, causing them to vibrate for several seconds. In so far as the published reports give information, the shock would seem to have been limited to the area along the river St. Lawrence, extending from near Three Rivers on the east, to Kingston on the west, and in a direction transverse to the St. Lawrence from Ottawa to the southern part of New England. In a paper prepared for the American Journal of

Science, by Professor Rockwood, of Princeton, he defines the area in question as that of "an irregular trapezium whose angles are marked by Pembroke, Ont., Three Rivers, P.Q., Hartford, Conn., and Auburn, N. Y., and which is some 200 miles on its northern and southern sides, about 300 miles on the eastern side, and 175 on the western." So far as can be learned from the reports, the shock seems to have been most severely felt on the north side of the valley of the St. Lawrence and about Lake Champlain, or may be said to have had its centre in the Adirondack and Green Mountain region.

In the notice of Canadian earthquakes in 1860, I mentioned that it had been observed that the greatest and most frequent shocks have occurred a little after the middle and toward the close of each century. We are now approaching the latter period, so that possibly the last shock may be the beginning of a series of similar phenomena. Since, however, there is no known reason for this periodicity, it may be a merely accidental coincidence, or may depend on some cycle of about half a century.

If we add to the table of earthquakes in Eastern America, given in Vol. V. of the *Naturalist*, the more recent earthquakes observed in Canada, the proportion for the several months will stand as follows:—

January, 9 earthquakes; February, 4; March, 5; April, 5; May, 7; June, 3; July, 4; August, 6; September, 4; October, 8; November, 15; December, 8. Total, 78.

Thus of seventy-eight recorded Canadian and New England earthquakes, fifteen, or nearly one-fifth, occeured in November; forty, or more than half of the total number, in the third of the year, extending from October to January inclusive. The published catalogues show that similar ratios have been observed elsewhere, at least in the Northern hemisphere.

In some earthquakes a low state of the barometer has been observed, as if a diminution of atmospheric pressure was connected with the movements of the crust producing seismic vibrations. This we can readily understand if a low state of the barometer should prevail over an area of the crust tending to rise, simultaneously with a high pressure over a sinking area. In this case a state of previous tension might terminate in a rent of the crust causing vibration. In the present case no very decided indication of such a cause appears, at least in so far as this part

of the St Lawrence valley is concerned. Mr. McLeod informs me that the mean barometer for the week preceding the earthquake was 29.7564, and for the following week 30.0864. The barometer on the Friday before the earthquake at 8 p. m. was 29.115, the lowest observed since March last; but at 1.50 a. m. on Saturday it was about 29.967, which is very near the mean of November 1876, and also a little above the mean barometer of the place for the whole year; and on Sunday afternoon it rose to 30.200. It would thus appear that the earthquake was preceded by a low state of the barometer, and followed by one unusually high for the season, and this rapid fluctuation was accompanied with much atmospheric disturbance in the region of the Lakes and the St. Lawrence Valley. The weather map issued by the War Department at Washington for Sunday morning, November 4th, shows a low barometer in the Gulf of St. Lawrence and a high barometer in the Middle States—the area of the earthquake being about half way between the extremes.

In connection with previous earthquakes it has been observed that the greatest intensity of the shocks appeared near the junction of the Laurentian with the Silurian formations. This would be a natural consequence either of the propagation of vibrations upwards from deep underlying regions through the Laurentian rocks, or from the overlying sedimentary rocks towards these older rocks. In the case of the recent earthquake, this appears to have applied chiefly to the border of the Laurentians extending round by the Ottawa and Kingston to the Adirondacks, as if a wave propagated through the Silurian formations had broken against the southern and eastern sides of the Laurentian region, or a shock originating under the Laurentian of these regions had extended itself from them into the Silurian rocks to the south and east. If the prevailing impression stated in the reports, that the vibrations passed from W. to E. or N.W to S.E., is correct, the latter would be the more probable supposition. It is, however, very difficult to attain to any certainty as to the actual direction of the disturbance, and some observers give it as precisely the opposite of that above stated.

In the present year there have been violent earthquake shocks along the chain of the Andes. The latest of these heard of was that of Lima and Callao on the 9th of October. On the west coast of North America, portions of Oregon and Washington

Territories were shaken on the 12th October. On the 14th November a slight shock was felt at Cornwall, Ontario, and on the 15th November earthquake shocks occurred over a wide area in Kansas, Iowa, Dakota and Nebraska.

While the above was in press the following appeared in the daily newspapers:—

"A despatch from Beachburg says:—Two shocks of earthquake were felt here this morning (Dec. 18), the first being between the hours of one and two, and the last between five and six o'clock, the latter being so severe as to shake houses and arouse the inmates from their slumbers."

Beachburg is on the south side of the Ottawa, about twelve miles north-west of Portage du Fort.